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The Short-term Effects of Three Molluscicides on the Microflora and Microfauna of Small, Biologically Stable Ponds in Southern Rhodesia *

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Where large-scale molluscicide applications are anticipated, it is important to investigate the effects of the chemicals to be used on the freshwater microflora and fauna existing in the bodies of water to be treated. The food chains of which these organisms form basic parts are important in the general ecology leading up to fish and even to man. Some observations on the direct short-term effect of three molluscicides—copper sulfate, sodium pentachlorophenate and Bayer 73—on the populations of certain plankton organisms, carried out in biologically stable ponds in Southern Rhodesia, are reported on in this paper. It appears that copper sulfate has the most drastic and long-lasting effects on these organisms. The authors stress that snail control measures involving molluscicides should be so designed as to effect the minimum alteration to the ecological balance of the freshwater habitat.

INTRODUCTION

In the past the application of molluscicides to natural watercourses, ponds and reservoirs has been carried out without much regard to the various ecological balances existing between the plankton and benthon which occur in biologically stable water systems. Cautionary remarks pertaining to the use of insecticides such as DDT in the control of aquatic insects have been made by Hynes (1960). Other workers (Barnley & Prentice, 1958) noted that the destruction of filter-feeding arthropods by DDT used in *Simulium* control in Uganda resulted in an increase of algal growth on rocks. With regard to snail ecology, Abdel Malek (1958) reports on the factors which condition the habitat of planorbid snails and makes mention of the periphyton, phytoplankton and other organisms which occur in the irrigation canals of the Gezira, Sudan. De Meillon et al. (1958) describe the ephemeropteran fauna associated with different speeds of water current and their relations with various snail species in flowing streams. They also make brief mention of the effect of copper sulfate on some freshwater organisms other than planorbids. No one, to the knowledge of the authors, has made detailed studies of the effects on these organisms of molluscicidal compounds.

Snail control in Southern Rhodesia is based on a large-scale blanket application of molluscicides covering all natural waters and artificial lakes within a prescribed area. Treatment is always carried out from the source of streams downwards and within catchment areas. After this blanket treatment the area is placed under focal control and mollusciciding is only carried out in those restricted places where snails are found to be surviving. In this way the extent of mollusciciding is usually limited, and no body of water is likely to be subjected to continual application which might result in a build-up of the chemical concerned to levels high enough to influence permanently the normal ecological balances within the habitat.

In case several re-applications should be necessary, however, it was felt that it would be desirable to investigate the short-term effects of molluscicides on small, biologically stable ponds. This would assist in finding out what happens to the various planktonic organisms, which are extremely important in the ecological chain, providing as they do adequate foods for fish populations. The latter often serve as a major source of animal protein for the indigenous population.

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MATERIALS AND METHODS

Three molluscicides were considered in these experiments—namely, copper sulfate, sodium pentachlorophenate and Bayer 73.

The tests were carried out in a series of small fish ponds 4×4 metres in area, each shelving rapidly from the edge to a depth of 60 cm. The ponds are adjacent and similar in appearance. Normally they are interconnected by means of a water furrow, but for the purpose of the trials the furrow was closed and the ponds remained isolated. The only water entering was rain which fell directly into the ponds. The macro vegetation in each of the ponds is similar and consists of large patches of the alga *Chara* sp., *Potamogeton pusillus* L. and *Polygonum salicifolium* Browass *ex* Will. The area around the ponds is covered with the grass *Leersia hexandra* Sev., but this is kept mown to a height of 6-10 cm above the water level. The only other large plant in the area was a species of *Typha* which occurs in Pond 4. No fish exist in the pond, but amphibia (*Xenopus laevis* Dard, *Rana* spp.) are common, as are crabs (*Potamon* sp.) and dytiscid and gyrinid beetles. The ponds are not lined with cement or any such substance, but are merely rectangular holes cut into a very rocky, lateritic soil.

The method of sampling was as follows. Six stations were marked on each pond, and samples were always taken from these stations. Each sample consisted of 2 litres of water collected in a 1000-ml measuring cylinder by inverting the vessel, plunging it into the water and then allowing the air contained therein to escape at the level required. In every instance one litre was taken from the surface to a depth of approximately 10 cm and one litre from approximately 30 cm lower down. The sample was filtered through a fine silk plankton net and the residue washed with a small quantity of water into a jar. The material was preserved in 4% formalin. Each sample was then examined in the following manner.

The plankton collected was poured into a measuring cylinder and made up to 100 ml. The contents were agitated to give an even suspension and 10 ml were rapidly drawn off. The 10-ml sample was placed on a 9-cm Petri dish, the bottom of which was divided into quadrants. One quadrant contained eight subdivisions, each being 1/32nd of the full circle; the second quadrant was divided in four, each being 1/16th of the full circle; the third quadrant was divided in two; and the fourth was undivided. The sample was evenly distributed in the dish and examined under a binocular microscope. All individuals lying with 2/32nds and 2/16ths were counted. It was possible to classify them under the following headings: Cladocera, Insecta (larval Diptera, Tricoptera, Coleoptera, Neuroptera, Odanata and Ephemeroptera, adult Gyrinidae, Gerridae, Dytiscidae) and acarines, Copepoda, *Copepod nauplii*, Ostracoda (*Cypris* and others), and *Spirogyra*. A few Rotifera were seen, but as they appeared only spasmodically, their numbers were excluded; this was also the case with some diatoms. After counting, the sample was discarded and a second 10-ml aliquot was taken and examined under the same conditions. The results were averaged, and using the simple formula,

$$\frac{(2a + b)}{2} \times 16 \times 100 = N,$$

where a is average number in 1/32 and where b is average number in 1/16, it was possible to estimate the total number (N) in the sample.

In order to test the validity of the sampling method, an analysis of variance was carried out on the observations made on the control pond during the experimental period. The results showed that the number of samples taken was reasonably adequate. From a perusal of the various graphs it can be seen that in all groups the fluctuations of the populations within the control pond were not very great. On these grounds it is felt that the sampling method can be accepted as adequate.

Analysis of the physical properties of the waters was carried out and, to obviate population differences due to diurnal fluctuations, all sampling was done between 10.30 a.m. and 11.30 a.m. (see the accompanying table).

PARTIAL WATER ANALYSIS OF PONDS [a]

Pond	pH	Total dissolved solids (p.p.m.)	Turbidity [b]	Treatment
1	7.7	145	6	20 p.p.m. $CuSO_4$
2	7.9	165	9	5 p.p.m. NaPCP
3	7.7	197	2	1 p.p.m. Bayer 73
4	7.7	197	2	Control

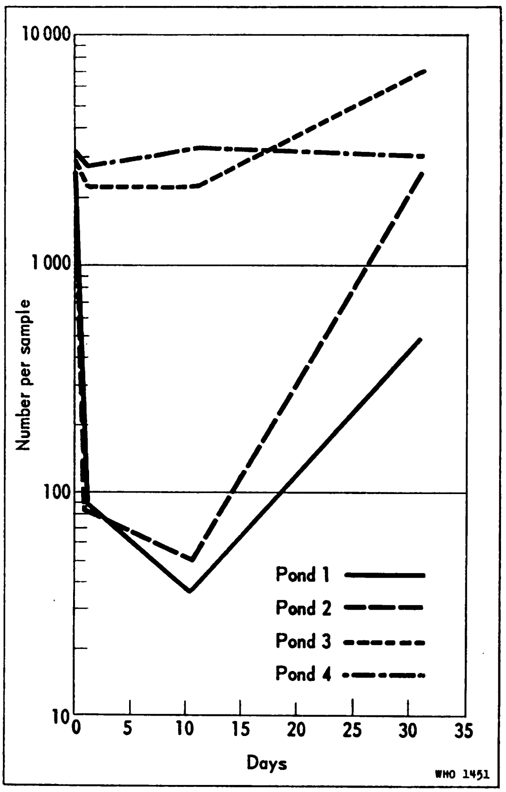
[a] Temperatures recorded were: Day 0, 25.5°C; Day 2, 28°C; Day 11, 22°C; Day 32, 27°C.
[b] Readings on Eel Nephelometer: distilled water = 0; clear tap water = 4-6.

RESULTS OF EXPERIMENTS

The chemicals were applied in appropriate strengths on Day 0 after the water samples were taken. Pond 1 was treated with copper sulfate at 20 parts per million of the crystalline salt. Pond 2 was treated at 5 p.p.m. with sodium pentachlorophenate, and Pond 3 with Bayer 73 at 1 p.p.m. of the 70% wettable powder. Pond 4 was untreated.

The over-all short-term effect is clearly demonstrated in Fig. 1, which records the population fluctuations of the total number of individuals in all groups. The immediate effect of both sodium pentachlorophenate and copper sulfate is to reduce the population very considerably, while only a slight reduction is apparent in the pond treated with Bayer 73 (Pond 3). In all ponds except that treated with copper sulfate, repopulation takes place within the period under observation. The effect of copper sulfate is more permanent.

FIG. 1
FLUCTUATIONS IN TOTAL NUMBERS OF MICROFLORA AND MICROFAUNA SAMPLED IN PONDS TREATED WITH DIFFERENT MOLLUSCICIDES [a]



[a] Samples were taken on days 0, 2, 11 and 32. Pond 1 was treated with copper sulfate at 20 p.p.m., Pond 2 with sodium pentachlorophenate at 5 p.p.m., and Pond 3 with Bayer 73 at 1 p.p.m. Pond 4 is the untreated control.

As can be seen from Fig. 2, the Cladocera are very sensitive to the action of the molluscicides. They disappear from the pond treated with copper sulfate and the recovery from the effect of sodium pentachlorophenate is very slow. The effect of Bayer 73 is very brief and the initial reduction is followed by an enormous increase in the population. This rapid build-up of Cladocera has its influence in the over-all figures in Fig. 1.

The effect on aquatic insects (Fig. 2) is not very pronounced in the case of sodium pentachlorophenate; it is erratic with Bayer 73, but extremely severe with the copper sulfate treatment.

Both the copepods and their *nauplii* larvae show a similar pattern (Fig. 2). The populations are severely reduced, but this reduction is short-lived and a rapid build-up takes place.

The ostracods (Fig. 2) are least affected by sodium pentachlorophenate but are more severely retarded by the other two compounds, although by the end of the period an upward trend both in the copper sulfate and Bayer 73 ponds was noted.

The effects of the three molluscicides on *Spirogyra* (Fig. 2) lead to very erratic population fluctuations. It appears that both with Bayer 73 and sodium pentachlorophenate, after an initial decrease in the population, *Spirogyra* are stimulated to a rapid regrowth once the residual action of the compound has dissipated.

GROSS EFFECTS OF MOLLUSCICIDES

Amphibia are not killed by copper sulfate at 20 p.p.m., but in the other treatments they die very rapidly. This effect is also noticeable with the larger crustacean decapods (*Potamon* sp.).

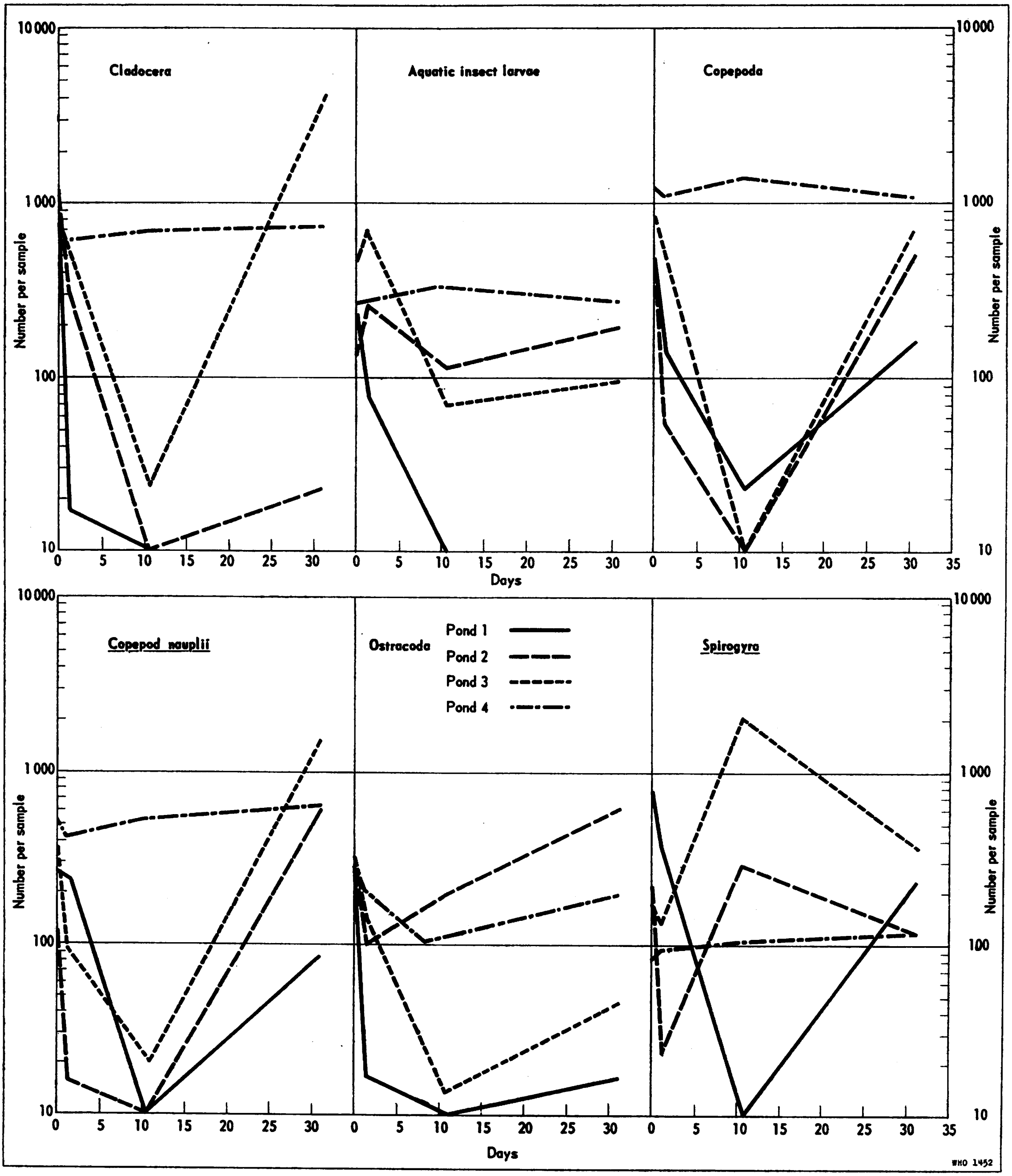
Both copper sulfate and Bayer 73 cause a severe setback to the dense beds of *Chara* sp. which occur in all the ponds. In the case of the latter compound, however, no visible effect on higher forms of plant life was noted. Sodium pentachlorophenate causes a very severe scorching of all forms of plant life but the effect is short-lived and recovery is much more rapid than in the pond treated with copper sulfate.

CONCLUSIONS

It appears from the evidence which has been collected that during the period under observation, the short-term effects of molluscicides applied to bio-

FIG. 2

FLUCTUATIONS IN GROUPS OF MICROFLORA AND MICROFAUNA SAMPLES IN PONDS TREATED WITH DIFFERENT MOLLUSCICIDES



See note to Fig. 1. For convenience, acarines have been included among the aquatic insect larvae.

logically stable ponds are marked by the immediate reduction of all forms of planktonic life. With sodium pentachlorophenate and Bayer 73 this effect is generally short-lived and 32 days after the chemicals have been applied population trends are back to normal. In the case of copper sulfate the picture is different; both insects and Cladocera are eliminated and do not reappear within the period under observation. This more prolonged effect of copper sulfate on the planktonic organisms is clearly demonstrated in Fig. 1, where the slow recovery of Pond 1 can be compared with the recovery in Ponds 2 and 3.

As copper sulfate in the concentrations normally used to kill adult snails is not effective on snail eggs, two applications within a short period of time are required if any degree of efficient control is desired.

It is clear from these experiments that those compounds which are thought to be the most efficient as molluscicides are also extremely toxic to other forms of life occurring in the freshwater biotope. Of the three tried, copper sulfate seems to be the most severe, especially when it is remembered that this chemical will have to be used twice within a fairly short period of time, owing to its lack of ovicidal properties. Schemes involving wide-scale use of molluscicides should be designed so as to ensure efficient snail control with minimum alteration to the ecological balance of the freshwater habitat.

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RÉSUMÉ

Pendant longtemps, on s'est livré à des expériences sur le pouvoir molluscicide de certaines substances chimiques, dans la nature, sans se soucier de l'effet qu'elles avaient sur la flore, la faune, et la chaîne alimentaire aboutissant aux poissons et à l'homme. Les auteurs étudient dans cet article l'action du sulfate de cuivre, du pentachlorophénate de sodium et du Bayer 73 sur la flore et la faune de petits étangs creusés dans des rochers latéritiques en Rhodésie du Sud. Les groupes considérés comprenaient des cladocères, des insectes (larves de diptères, tricoptères, coléoptères, nevroptères, odonates et éphéméroptères, adultes de gyrinides, gerridés, dytiques), acariens, copépodes, ostracodes, et spirogyres.

Les données recueillies au cours de la période d'observation montrent que l'application de molluscicides à des étangs biologiquement stables provoque immédiatement une réduction du nombre de toutes les formes planctoniques. Avec le pentachlorophénate de sodium et le Bayer 73, cette action est généralement brève et, 32 jours après l'application des produits, les courbes de population sont redevenues normales. Dans le cas du sulfate de cuivre, le tableau est différent: les insectes, de même que les cladocères, sont éliminés et ne réapparaissent pas pendant la période d'observation.

Etant donné qu'aux concentrations où on l'utilise normalement pour tuer les mollusques adultes, le sulfate de cuivre n'agit pas efficacement sur les œufs de mollusques, deux applications sont nécessaires dans un intervalle assez bref si l'on veut arriver à une certaine efficacité dans la lutte anti-mollusques.

D'après ces observations, il semble que si l'on doit procéder à des applications successives d'un molluscicide pour lutter avec succès contre les mollusques tout en ne provoquant que des altérations minimums de l'équilibre écologique, il serait préférable d'employer le pentachlorophénate de sodium ou le Bayer 73 plutôt que le sulfate de cuivre, car celui-ci, en application isolée, semble exercer l'action la plus perturbatrice sur l'équilibre d'un milieu aquatique biologiquement stable.

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